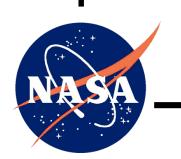DRAFT

LANDSAT DATA CONTINUITY MISSION

STATEMENT OF WORK
FOR THE
OPERATIONAL LAND IMAGER

June 29, 2005

Goddard Space Flight Center
Greenbelt, Maryland

National Aeronautics and
Space Administration

DRAFT

LDCM PROJECT
DOCUMENT CHANGE RECORD

Sheet: 1 of 1

REV LEVEL	DESCRIPTION OF CHANGE	DATE APPROVED

List of TBDs/TBRs

Item No.	Location	Summary	Ind./Org.	Due Date

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1.0 **INTRODUCTION**

1.1 **GENERAL**

This Statement of Work (SOW) defines the minimum effort required by the Contractor for the design, analysis, development, fabrication, integration, algorithm development, test, evaluation, delivery, and support for the Landsat Data Continuity Mission (LDCM) Operational Land Imager, hereafter referred to as OLI. This Statement of Work requires delivery of two OLI instruments. The instruments shall meet the requirements of the OLI Specification. The Flight Model (FM)-1 instrument shall be designed for accommodation on the National Polar-orbiting Operational Environmental Satellite System (NPOESS) C1 spacecraft. The FM-2 instrument shall be designed for accommodation on the NPOESS C4 spacecraft. The OLI shall meet the requirements of the current revision of the NPOESS General Instrument Interface Document and the OLI/NPOESS 2130 Spacecraft Interface Requirements Document, and as modified by accepted exceptions documented in the Spacecraft-to-Instrument Interface Control Document.

1.2 **SCOPE**

In accordance with the requirements of the OLI Specification and the other attachments to this contract, the Contractor shall provide the personnel, materials, equipment, and facilities necessary for the design, analysis, development, fabrication, assembly, test, engineering data analyses, calibration, qualification, delivery, and support of the OLI. The OLI consists of the Reflective Band Sensor (RBS), which includes any accommodation hardware and software required to meet the OLI Specification, and the Data Storage and Playback Subsystem (DSAP).

The Contractor shall deliver to the spacecraft vendor's facility an FM-1 OLI that is fully tested, calibrated, has demonstrated reliable operation in accordance with the OLI Mission Assurance Requirements (MAR) and is ready for integration with the spacecraft and ready to support spacecraft level testing. The Contractor shall deliver to storage an FM-2 OLI that is ready for integration with the spacecraft and ready to support spacecraft level testing.

The Contractor shall comply with GSFC-STD-1000, "Rules for the Design, Development, Verification, and Operation of Flight Systems." The Contractor shall provide a list of exceptions to compliance with GSFC-STD-1000 in accordance with CDRL PM-12.

Following FM-1 OLI delivery the Contractor shall support post-delivery testing, spacecraft integration, spacecraft test, and preparation of the integrated spacecraft for shipment to the launch facility. At the launch facility the Contractor shall provide pre-launch support. The Contractor shall provide post-launch support for OLI functional test, verification of on-orbit performance, and anomaly resolution. Following FM-2 OLI delivery, the Contractor shall provide periodic testing of the FM-2 while in storage. In support of the above activities, the Contractor shall provide the required reports, reviews and documentation identified in the contract.

The Contractor shall provide the personnel, materials, facilities and other resources to design, develop, deliver and support under the basic contract: two Flight Model OLIs (FM-1 and FM-2),

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one Engineering Development Unit OLI, one Structural Thermal Model OLI, four Instrument Electrical Simulators, all GSE, all spares for all the above, and all items and documents specified in the contract.

2.0 <u>APPLICABLE DOCUMENTS</u>

The Contractor shall comply with the following documents:

Operational Land Imager Specification: Document Number 427-50-01-001

Operational Land Imager Special Test Requirements: Document number 427-40-02-001

Operational Land Imager to Spacecraft Interface Requirements Document: Document number 427-50-01-003

Operational Land Imager Contract Data Requirements List: Document number 427-50-01-004

Operational Land Imager Mission Assurance Requirements: Document Number 427-50-01-005

Operational Land Imager Acronym List and Lexicon: Document Number 427-50-01-006

Top of Atmosphere Radiance Values, MODTRAN 4 Model. http://ldcm.nasa.gov/... TBS

NIST 2000 realization of scale of spectral irradiance, H. W. Yoon, C. E. Gibson and P. Y. Barnes, The realization of the NIST detector-based spectral irradiance scale, Metrologia 40 (2003) S172–S176.

NPOESS General Instrument Interface Document (GIID), NGST Doc. No. D31418

NPOESS Payload Engineering Development Unit (EDU) Specification, NGST Doc. No D40397

NPOESS 1553 Interface Requirements Document, NGST Doc. No. D34470

NPOESS Sensor Simulator Specification, NGST Doc. No. D34641

Rules for the Design, Development, Verification, and Operation of Flight Systems, GSFC-STD-1000

General Environmental Verification Standard (GEVS), GSFC-STD-7000, April 2005

3.0 MANAGEMENT

3.1 PROJECT MANAGEMENT

The Contractor shall maintain a project office that shall manage the technical activities and resources of the OLI project. The Contractor shall appoint a dedicated Project Manager to direct and manage the OLI project. The Contractor's Project Manager shall have responsibility for the overall technical performance and resource management of the contractual effort and all subcontracts. The Contractor's designated Project Manager shall report to a level of company management appropriate to ensure prompt resolution of all problems. The Contractor shall develop a Project Management Plan in accordance with CDRL PM-11 which addresses the overall organization, management approach, and structure of the OLI Project plus its interrelationships with the parent company and subcontractors, and its relationship with the Government. The Contractor shall develop and deliver an IT Security Plan in accordance with CDRL PM-13.

The Contractor shall establish and maintain a comprehensive risk management program in accordance with the OLI Mission Assurance Requirements (MAR). Risks and mitigation analyses shall include risks to the OLI performance, reliability, schedule, safety, and cost. Risk identification, analysis, planning, tracking, and control shall be performed on risks to the OLI performance, cost, and schedule. The Contractor shall maintain a risk log including the analysis, planning, and control status for each risk. The contractor shall generate a top risk report that is presented and reviewed at all Monthly Project Status Reviews (MPSRs). The Contractor shall develop and deliver a Risk Management Plan in accordance with CDRL PM-10.

The Contractor shall develop a closed-loop problem tracking process that includes problem or anomaly reporting, problem analysis, and corrective action. The process shall include: a protocol to review past performance to determine the incidence of identical or related anomalies, an escalation procedure (to inform higher levels of management and the Government) based on mission criticality, and a closeout process for root cause determination, anomaly mitigation, and recurrence control.

The Contractor shall provide to the Government, for review purposes, electronic access to all completed reports, analyses, requirements documentation, internal technical memoranda, Class II change requests and documentation, CDRLs, and all other documents relating to the development and management of OLI contained in electronic data bases customarily used by the contractor for projects such as OLI. Within the data bases the Contractor shall maintain an index of the material and update this index at least monthly. The material contained in these electronic databases may be in contractor format. The Contractor shall provide Contractor-Generated Internal Technical Information, as requested by the Government, in accordance with CDRL SE-2.

The Contractor shall provide suitable facilities, including office space, furniture, access to a conference room, file/storage area, and telecommunications access, to support one Government in-plant representative and one visiting Government representative.

The Contractor shall prepare a Final Report at the end of the contract period in accordance with CDRL PM-8.

3.2   RESOURCE MANAGEMENT

The Contractor shall implement an Earned Value System (EVS). The EVS may be implemented in accordance with the Contractor's standard plans and policies, provided it conforms to the minimum reporting requirements of NPR 9501.2D NASA Contractor Financial Management Reporting, including use of NASA Form 533 reports. The Contractor shall provide Financial Reports and Earned Value System Reports to the Government in accordance with CDRLs PM-5 and PM-6 and the contractor's standard policies and procedures. The Contractor shall develop and provide an EVS Baseline Review Package in accordance with CDRL PM-1.

The Contractor shall segregate, track, and report individual work efforts in accordance with the provided Work Breakdown Structure (WBS). The Contractor shall develop and deliver a WBS Diagram and Task Description Updates in accordance with CDRL PM-2.

3.3   CONFIGURATION MANAGEMENT

The Contractor shall establish and maintain a configuration management system. This system may be in accordance with the contractor's standard plans and policies, provided the configuration management requirements identified in the MAR document are satisfied. The Contractor shall provide configuration management of the Engineering Development Unit (EDU) and simulators as well as the flight hardware. The Contractor shall deliver a Configuration Management Plan in accordance with CDRL PM-9 that describes the scope, approach, methods, and procedures used to control changes of requirements and design. The Contractor shall submit for approval Configuration Change Requests for Class I changes in accordance with CDRL SE-1

3.4   REVIEWS AND MEETINGS

3.4.1   Weekly Informal Telecon

The Contractor shall participate in a weekly telecon with the LDCM Project Office to communicate status, issues, and schedule progress and plans.

3.4.2   **Monthly Project Status Reports**

The Contractor shall communicate the status of the technical effort, program schedule, and financial condition to the LDCM Project on a regularly scheduled basis. The Contractor shall conduct Monthly Project Status Reviews (MPSRs), including presentation package, in accordance with CDRL PM-4. The MPSR shall include Detailed Schedules in accordance with CDRL PM-3. The MPSR shall be conducted face-to-face unless otherwise agreed in advance.

3.4.3 Technical Interchange Meetings

The Contractor shall conduct informal Technical Interchange Meetings (TIMs) with the Government on technical issues arising during the program, specifically concerning performance or reliability issues. Either the Contractor or the Government may request a TIM. The Contractor shall track action items arising from TIMs for resolution/response and report status at the MPSRs.

The Contractor shall conduct Technical Interchange Meetings with subcontractors for issues concerning critical assemblies and subassemblies and provide the Government 10 days advanced notice so that the Government can attend.

3.4.4 Peer Reviews and Packaging Reviews

The Contractor shall conduct a program of peer reviews at the component and subsystem level and during all phases of the project life cycle. The Contractor shall conduct packaging reviews on all electrical and electromechanical components in the flight system including electrical interconnection harness design and assembly requirements.

At the peer reviews, the Contractor shall evaluate the ability of the component or subsystem to successfully perform its function under operating and environmental conditions during both testing and flight. The Contractor shall present the results of analyses, including the results of associated tests.

The packaging reviews shall specifically address the following: Placement, mounting, and interconnection of EEE parts on circuit boards or substrates, structural support and thermal accommodation of the boards and substrates and their interconnections in the component design, and provisions for protection of the parts and ease of inspection.

The Contractor shall conduct hardware design peer reviews with personnel who are not directly responsible for design of the hardware under review. To promote continuity of the whole review program and allow for participation of the Goddard Space Flight Center (GSFC) LDCM Project and System Review Office, the Contractor shall provide the peer review schedule to the GSFC LDCM Project. The Contractor shall plan for Government participation in the peer review process. The Contractor shall document the results of the reviews in Peer Review Data Packages in accordance with CDRL RE-2.

3.4.5 Test Status and Planning Meetings

The Contractor shall allow the Government access to Contractor test status and planning meetings.

3.4.6   Major Instrument Progress Reviews

In addition to MPSRs, TIMs, and peer reviews, the Contractor shall prepare and conduct the following external independent major progress reviews and provide review packages in accordance with CDRLs RE-1, RE-3, RE-4, RE-5, and RE-6:

Instrument System Requirements Review (ISRR)
Instrument Preliminary Design Review (IPDR)
Instrument Critical Design Review (ICDR)
Instrument Pre-Environmental Review (IPER)
Instrument Pre-Ship Review (IPSR)

The Contractor shall prepare and conduct design reviews (PDR and CDR) and Pre-Ship Reviews for all subsystems, including, but not limited to, the focal plane assembly, telescope, and DSAP.

These reviews should not be considered a comprehensive set of reviews for the Contractor's program. Additional reviews that the Contractor deems necessary to successfully execute the program should be conducted at the Contractor's discretion. In general, the Contractor shall notify the Government at least 10 working days in advance of lower level Contractor subsystem reviews to allow the Government time to attend the review as part of its insight activities.

3.4.7   Support to NPOESS Mission Level Reviews

The Contractor shall prepare Data in Support of Mission Level Reviews in accordance with CDRL RE-7. NPOESS Mission Level Reviews are briefed chiefly by the spacecraft contractor to NPOESS government management to provide status and readiness to accomplish the NPOESS mission. The Contractor shall participate in Mission Level Reviews as requested by the Government, and respond to action items from Mission Level reviews. These Mission Level Reviews are nominally the System Definition Review (SDR), Preliminary Design Review (PDR), Critical Design Review (CDR), Pre-Environmental Review (PER), Mission Operation Review (MOR), Pre-Ship Review (PSR), Flight Operation Review (FOR), Operation Readiness Review (ORR), Mission Readiness Review (MRR), Flight Readiness Review (FRR), the Launch Readiness Review (LRR), and the Initial Operational Capability Review (IOCR).

3.4.8   Support to LDCM Mission Level Reviews

The Contractor shall prepare Data in Support of Mission Level Reviews in accordance with CDRL RE-7. LDCM Mission Level Reviews are briefed by participants in the LDCM mission to NASA government management on the status and readiness of the LDCM to accomplish its mission. The Contractor shall participate in Mission Level Reviews as requested by the Government, and respond to action items from Mission Level reviews. These Mission Level Reviews are nominally the System Definition Review (SDR), Preliminary Design Review (PDR), Mission Confirmation Readiness Review (MCRR), Critical Design Review (CDR), Pre-Environmental Review (PER), Mission Operation Review (MOR), Pre-Ship Review (PSR), Flight Operation Review (FOR), Mission Readiness Review (MRR), the Launch Readiness Review (LRR), and the Initial Operational Capability Review (IOCR).

The Contractor shall prepare status and summary charts, participate in, and respond to action items from a post-launch review of spacecraft and instrument performance.

3.4.9   Responses to Formal Actions

The Contractor shall develop and apply a process for capturing and responding to review action items identified by the Government. The Contractor shall provide Responses to Formal Actions (RFAs) in accordance with CDRL PM-7. Major progress reviews, as defined above, are not complete until actions are dispositioned, subject to the approval of the Contracting Officer.

4.0 <u>SYSTEM ENGINEERING</u>

The Contractor shall perform systems engineering efforts necessary to assure that all requirements of this contract are accomplished successfully and on time. Systems engineering includes, at a minimum, all technical and management efforts of directing and controlling an integrated engineering effort for the project. This includes requirements definition, allocation, and traceability, requirements change control and documentation, systems engineering trades and analyses, technical performance tracking and control, and verifying conformance of the system to the requirements. Systems engineering also consists of definition and control of internal and external interfaces.

4.1 OLI SYSTEMS ENGINEERING

The Contractor shall perform all required OLI systems engineering efforts to assure that all requirements of this contract are accomplished successfully and on time. These systems engineering functions shall include the following:

a. Definition, allocation, and traceability of system and subsystem requirements and verification approach.
b. Develop and deliver Approved or Controlled Drawings, and Wiring Diagrams in accordance with CDRLs SE-8 and SE-7.
c. Test and calibration requirements definition, including planning for demonstration of compliance with the OLI Specification, the Special Test Requirements (STR), and the MAR.
d. Develop and deliver the Calibration Validation Plan in accordance with CDRL CV-1.
e. Conduct test evaluation and test reporting.
f. Perform OLI performance trending, analyze trend data, and provide Trending Reports in accordance with SE-4. The Contractor shall perform trending within the normal test framework; i.e., during functional tests, environmental tests, etc. The Contractor shall establish a system for recording and analyzing the trending parameters as well as any changes from the nominal even if the levels are within specified limits.
g. Develop and deliver the Contamination Control Plan in accordance with CDRL SA-13.
h. Direct and control an integrated engineering effort for the project.
i. Provide technical support to the risk management program.
j. Perform an OLI line of sight jitter analysis based upon the OLI mechanical and optical models and the spacecraft interface requirements to verify that the design meets the requirements of the specification.
k. Prepare and conduct table-top reviews of instrument test results with the Government, scheduled as deemed appropriate by the Contracting Officer's Technical Representative (COTR).
l. Conduct and/or support reviews as required, including response to action items.
m. Manage internal OLI interfaces.
n. Document spacecraft interface and requirements information in accordance with CDRL SE-12, OLI Interface Requirements Document.

o. Define and control the instrument to spacecraft interfaces until a spacecraft to instrument ICD is completed by the spacecraft vendor. The Contractor shall develop and maintain Interface Control Documents Inputs in accordance with CDRL SE-11.

p. Interface and coordinate with the spacecraft contractor in development, design and test of spacecraft interfaces, including attendance at meetings at the spacecraft contractor's facility. Provide inputs to spacecraft-level testing plans and procedures. Participate in spacecraft interface, integration, and testing working groups.

q. Maintain and control critical OLI technical performance metrics and margins.

r. Provide the Orbital Debris Assessment Inputs in accordance with CDRL SA-15.

s. Provide an OLI Data Users Manual in accordance with CDRL OO-3.

t. Provide the Operation and Maintenance Manuals in accordance with CDRL00-4.

4.2 SYSTEMS ANALYSIS

The Contractor shall, in coordination with systems engineering activities, perform the necessary analyses to assure that all requirements of this contract are accomplished successfully and on time. These systems engineering analyses shall include, but are not limited to, the following; visible and infrared Reflective Band Sensor (RBS) radiometry, spatial, spectral, optics, polarization, stray light (including stray light from spacecraft and reflected off solar diffuser), electronics, structure, thermal system, contamination, optical/electrical/radiometric sensitivity to temperature changes, line of sight jitter, pointing knowledge error budget, and DSAP throughput analyses. All analyses performed by the contractor under this contract shall be provided in accordance with the Engineering Analyses and Test Reports CDRL SE-3.

4.3 SPECIAL STUDIES, ANALYSES, AND TASKS

The Contractor shall prepare, in addition to the requirements specified in this document and the contract, additional engineering studies, technical analyses, design modifications, and tasks as requested by the COTR. In advance of initiation of any work associated with these activities, the contractor shall propose to the COTR the specific task elements which will be performed, and the labor and materials costs associated with the effort. For planning purposes, the Contractor should anticipate that most of the studies and tasks will be performed prior to ICDR. In addition, the Contractor may propose Engineering Analyses and Tests. Results of special studies, analyses, and tests, whether Government or Contractor proposed, shall be reported in Engineering Analysis and Test Reports in accordance with CDRL SE-3.

5.0 FLIGHT MODEL 1 (FM-1) AND FM-2 DESIGN AND FM-1 DEVELOPMENT

5.1 DESIGN ENGINEERING

The Contractor shall provide all personnel, equipment and facilities necessary for the design and development effort of the OLI FMs. This effort shall include the electrical, structural, mechanical, thermal, data, and safety and reliability design of the OLI, the OLI to spacecraft interface design, command and data formats, the RBS calibration, and ground support equipment. The OLI shall include the Reflective Band Sensor (RBS) and the Data Storage and Playback (DSAP) Subsystem. The RBS shall contain the optical subsystem, the calibration subsystem, focal plane and focal plane electronics, the optical bench, and any NPOESS accommodation hardware. The DSAP shall include the data storage subsystem and the data handling and formatting subsystem. The Contractor shall choose the location of the instrument control electronics.

5.1.1 Algorithms and Mathematical Models

The Contractor shall develop and provide OLI algorithms and models as defined below:

5.1.1.1 Algorithms and Calibration Parameters

The Contractor shall develop and deliver Algorithms and Calibration Parameters in accordance with CDRL CV-7.

5.1.1.2 Radiometric Math Model

The Contractor shall develop, deliver, and maintain a Radiometric Math Model in accordance with CDRL CV-5.

5.1.1.3 Thermal Math Model

The Contractor shall develop and maintain a Thermal Math Model in accordance with CDRL SE-6

5.1.1.4 Structural Math Model

The Contractor shall develop and maintain an OLI Structural Math Model in accordance with CDRL SE-5. The Contractor shall verify the accuracy of the model with dynamic test data. The Contractor shall update the model to agree with the structural test results.

5.1.1.5 OLI Optical Analytical Model

The Contractor shall develop, and maintain an OLI Optical Analytical Model in accordance with CDRL CV-6. The Contractor shall verify the accuracy of the model with hardware testing. The Contractor shall update the model to agree with the test results.

5.1.1.6 Stray Light and Ghosting Model

The Contractor shall develop the Stray Light and Ghosting Model in accordance with the STR and make the model available for review at the Contractor's facility.

5.1.1.7 Line-of-Sight Processing Algorithms

The Contractor shall develop and deliver Line-of-Sight Processing Algorithms in accordance with CDRL CV-8.

The Contractor shall demonstrate that the end-to-end requirements of paragraph 3.3.2 of the OLI Specification are satisfied by these algorithms. The Contractor shall document and deliver the results of the demonstration in accordance with CDRL CV-3.

5.1.2 Hardware Models

5.1.2.1 Structural Thermal Model

The Contractor shall develop a Structural Thermal Model (STM) of the OLI, to the extent required by the System Performance Verification Plan, to verify the structural, thermal, and opto-mechanical design meets performance requirements. Parts used on the STM may be transferred to the Engineering Development Unit (EDU) after completion of STM testing, provided they meet EDU requirements.

5.1.2.2 Engineering Development Unit

The Contractor shall develop an OLI Engineering Development Unit (EDU) to evaluate design decisions, test electrical/data interfaces with the spacecraft, mitigate risk, and to provide a test bed for anomaly resolution for the flight model instruments. The EDU shall meet the requirements of D40397, NPOESS Payload Engineering Development Unit (EDU) Specification, with the exceptions that sensor data shall not be simulated and the EDU shall be the same as the flight model in form and fit. The EDU shall be the same as the flight model in form and fit, however, performance does not need to fully meet specification. The Contractor shall present and discuss with the Government the planned functionality level of the EDU at the IPDR. The EDU focal plane assembly shall be fully populated. The EDU shall have optics sufficient to produce an image for electrical/data flow evaluation purposes. It shall incorporate parts and components of the same type called for in the flight model design, but they need not be flight-qualified. The Contractor shall also use the EDU to verify flight software, verify assembly procedures, test all deployable mechanisms, test the control electronics, and verify interfaces with the spacecraft. The Contractor shall demonstrate the interfaces of the separate EDU units, i.e., the interface of the RBS unit of the EDU with the DSAP unit of the EDU. The OLI EDU shall have the same mechanical mounting interfaces to the spacecraft as the flight model OLI. The Contractor shall conduct a pre-ship review for the EDU one week prior to shipment that addresses the configuration of the EDU, the readiness of the EDU to be used for spacecraft

interface testing, and EDU handling. The Contractor shall conduct EDU operations and handling training for the spacecraft contractor. The Contractor shall provide Training Manuals in accordance with CDRL OO-6. The Contractor shall ship the EDU to the spacecraft contractor facility for mechanical and electrical interface functional test, which lasts several months. The Contractor shall assist the interface functional test and return the EDU to the Contractor facility.

The Contractor shall maintain the EDU through for the duration of the contract period.

5.1.3   Instrument Simulator

The Contractor shall design, develop and deliver four instrument simulators to simulate OLI outputs and electrical interfaces and to interface with the spacecraft simulator.

The simulator shall meet the requirements of D34641, Sensor Simulator Specification, with the exception of paragraph 3.14.3. The simulator shall simulate all instrument modes and mode transitions. The simulator shall simulate predefined, scripted anomalies. The simulator shall communicate with a spacecraft simulator for instrument command, telemetry, and science packets. The simulator shall execute flight code. The simulator shall accept simulation control commands from either a standalone console or through the interface with the spacecraft simulator. The simulator shall generate housekeeping data reflective of commanded mode. The simulator shall accept real-time inputs to change simulated telemetry or modeling parameters. The simulator shall maintain a log of all instrument commands received indicating validity, command mnemonic, and raw bit pattern. The simulator shall maintain a log of all simulation directives received.

The Contractor shall conduct a preliminary review of the instrument simulator design in accordance with the requirements of CDRL RE-2 (Engineering Peer Review). Prior to the shipment of the first instrument simulator, the Contractor shall conduct a review of simulator performance and operation in accordance with the requirements of CDRL RE-2. The Contractor shall provide training on simulator operation to the spacecraft contractor. The Contractor shall provide Training Manuals in accordance with CDRL OO-6. The Contractor shall provide maintenance and troubleshooting support of all simulators for the duration of the contract period.

5.2   SUBASSEMBLY, ASSEMBLY, AND UNIT BUILD AND TEST

The Contractor shall provide all personnel, equipment and facilities necessary for the fabrication, assembly, and test of the OLI. The Contractor shall plan and perform tests, at the appropriate levels of assembly, which meet the minimum requirements of the MAR, NPOESS GIID, and STR. The Contractor shall have available for review by the Government the component and subassembly test reports for all subcontracted items.

5.2.1 Reflective Band Sensor

The Contractor shall provide all necessary engineering and management functions required to fabricate, assemble, test, and calibrate the OLI RBS. The OLI RBS includes the flight cables between the RBS and DSAP.

5.2.2 Data Storage and Processing System

The Contractor shall provide all necessary engineering and management functions required to fabricate, assemble, and test the DSAP.

5.3 OLI SYSTEM INTEGRATION AND TEST

5.3.1 Sensor/DSAP System Integration

The Contractor shall integrate the RBS and DSAP. The Contractor shall provide the personnel, facilities, special tools and equipment, and materials necessary to perform the integration.

5.3.2 System Functional and Environmental Testing

The Contractor shall verify that the OLI meets performance specifications after exposure to the environments required by the MAR/GEVS and as modified by the interface, environmental, and electromagnetic testing requirements in the NPOESS GIID. The NPOESS GIID environmental requirements take precedence over the environments specified in GEVS. The Contractor shall develop a System Performance Verification Plan (SPVP) in accordance with CDRL SE-9. After Contract award, the Contractor shall compare the test environments specified in the MAR with the environmental conditions specified in the NPOESS GIID. The Contractor shall participate in discussions with the Government to resolve these differences prior to release of test planning documentation (i.e., the SPVP) and document these agreed-to resolutions in the Instrument-to-Spacecraft ICD.

5.3.3 System Performance Testing

The Contractor shall provide all personnel, equipment, software, and facilities necessary to test the OLI and verify compliance with the OLI Specification, the MAR, and all spacecraft interfaces. The Contractor shall perform the OLI test program in accordance with the SPVP and shall calibrate the OLI in accordance with the Contractor-developed Calibration and Validation Plan. The Contractor shall develop and provide the Calibration and Validation Plan in accordance with CDRL CV-1. The Contractor shall implement the Calibration and Validation Plan. The Contractor shall provide spectral filter witness samples to the Government in accordance with Contract clause B.1, item A-10. The Contractor shall develop and provide Detailed Test Procedures in accordance with CDRL IT-3. The Contractor shall provide Calibration and Validation Procedures in accordance with CDRL CV-2. The Contractor shall provide Verification Reports and Calibration and Validation Test Reports in accordance with CDRLs SE-10 and CV-3, respectively. The Contractor shall provide Calibration and Validation Summary Reports in accordance with CDRL CV-4. The Contractor shall document and

investigate anomalies and perform anomaly resolution. Anomaly resolution is the identification, investigation, and resolution of anomalies including the characterization of a problem or deficiency, determination of the probable cause or missing functionality, evaluation against existing specifications and requirements, and providing analysis to the Government for prospective corrective actions or enhancements. The Contractor shall store and maintain all output data collected from the instrument during ground testing for anomaly resolution. The Contractor shall deliver an Acceptance Data Package in accordance with CDRL SA-7. The Contractor shall measure the mass and center of gravity of the RBS and DSAP prior to shipment.

5.3.4 Independent Testing

To maintain continuity of the Landsat data archives and calibration to the National Institute of Standards and Technology (NIST), the Contractor shall provide access to the Contractor's radiometric calibration sources sufficient for the Government and/or its subcontractors to conduct source characterization at the Contractor's facility. The Contractor shall also provide coordination and support sufficient for the Government and/or its contractors to conduct independent pre-launch measurements of the Contractor's radiometric calibration sources at the Contractor's facility.

For Government Transfer Radiometer testing, the Contractor shall provide access sufficient for the Government and/or its contractors to conduct source characterization in the Contractor's laboratory environment for a total of five 2-day periods; three 2-day periods prior to RBS calibration; and two 2-day periods after RBS calibration. In addition, the Contractor shall provide access sufficient for the Government and/or its contractors to conduct source monitoring during OLI calibration activities.

The Contractor shall provide access and support for two 4-day periods, one prior to RBS calibration with the calibration source and one after, for NIST/Earth Observing System (EOS) radiometric scale realization activities. The radiometric scale realization activities will involve viewing of the radiometric calibration source(s), typically large aperture integrating spheres, used by the Contractor to calibrate OLI. These sources will be viewed by a number of transfer radiometers and the results will be compared to the Contractor's calibration of this source. The Contractor shall supply access to and an operator for the radiometric calibration source as well as the current radiometric calibration of this source.

The Contractor shall account for these Independent Testing periods of access in the contract and program schedule. The Government shall provide reasonable notice of these periods of access.

5.4 SOFTWARE

The Contractor shall provide all software, including software required for spacecraft-level testing, required to meet the requirements of the OLI Specification, the MAR, and this SOW. The Contractor shall provide all personnel, hardware, and facilities to develop all flight and GSE software.

5.4.1 <u>Flight Software</u>

The Contractor shall treat the software component of firmware, which consists of computer programs and data loaded into a class of memory that cannot be dynamically modified by the computer during processing (e.g., programmable read-only memories (PROMs), programmable logic arrays, digital signal processors, FPGAs, etc.), as flight software for the purposes of this SOW.

5.4.1.1 Flight Software Management

The Contractor's program organization shall recognize the system level aspects of flight software by its position with other OLI subsystems. The Contractor shall demonstrate that the software has a high level of independent reporting and visibility within the management structure.

The Contractor shall perform industry accepted software management approaches to: software analysis, design, development, documentation, version control, test, validation, risk management, and assurance of all software products. This systematic approach shall be detailed in the Software Development and Management Plan in accordance with CDRL SW-1.

The contractor shall prepare and conduct flight software status reviews as part of the technical status portion of the Monthly Project Status Review (PM-4).

5.4.1.2 Flight Software Implementation and Delivery

The Contractor shall perform all analyses and software systems engineering required to allocate (from system and subsystem requirements) and identify software and software interface requirements.

The contractor shall develop and provide the OLI Data Format Control Document in according with CDRL SW-2.

The Contractor's software design shall be captured and maintained in the Software Design Document (SDD) in accordance with CDRL SW-3. This shall describe the architecture, structure, and organization of each software component (CSCI) and its sub-components (CSC). The SDD shall describe the interfaces, logic, data flow and unique data structures contained in each sub-component. Draft versions shall precede the final as-built version.

The Contractor's testing approach and methodology shall be documented in the Flight Software Test Plan in accordance with CDRL SW-7. All phases of the software testing, from informal routine and function tests through the Acceptance Tests shall be carried out conforming to the documented plan. Detailed testing procedures are captured and maintained in the Software Test Procedures and Software Test Reports in accordance with CDRLs SW-8 and SW-9. Electronic versions of test results shall be accessible. Final Software Acceptance Tests are documented, verified and validated through the Software Acceptance Review Data Package in accordance with CDRL SW-5.

With each delivery of verified and tested software, the Contractor shall concurrently deliver a Software Delivery Package (SDP) in accordance with CDRL SW-10.

Requirements, design, and code walkthroughs or inspections shall be conducted at the Contractor's facility at the appropriate software developmental life-cycle phase to ensure the correctness of the requirements, design, and source code. All Contractor and sub-contractor internal data, reviews, audits, meetings and other activities pertinent to the execution of the contract shall be open to Government review/attendance. The Contractor shall provide the Government with reasonable and timely notification, to facilitate Government attendance. Government OLI contractors may also attend these reviews, audits, and meetings at the Government's discretion.

5.4.1.3 NASA IV&V Support

The Contractor shall support NASA Independent Validation and Verification (IV&V) activities as required by the MAR.

5.4.2   Commands and Telemetry

The Contractor shall provide an OLI Command and Telemetry List and Description document in accordance with CDRL IT-2 containing descriptions and lists of all commands and command sequences necessary for successful operation of the OLI. The Contractor shall translate all OLI commands and command sequences for use by the spacecraft contractor's GSE.

5.4.3   Software Maintenance

The Contractor shall maintain OLI flight software throughout the life of the mission. The Contractor shall maintain flight software development tools and procedures in order to provide uninterrupted support for the life of the mission.

5.4.4   Software Reviews

The Contractor shall prepare and conduct a Software Requirements Review, a Software Preliminary Design Review and a Software Critical Design Review as part of the ISRR, IPDR and ICDR, respectively. The Software Requirements Review may be held after the ISRR, if necessary. The Contractor shall prepare and conduct a Software Test Readiness Review and a Software Acceptance Review in accordance with CDRLs SW-4 and SW-5. The Contractor shall prepare and conduct a GSE Software Test Readiness Review in accordance with CDRL SW-6.

5.4.5   GSE Software

The Contractor shall design and provide all software necessary to operate the GSE. The Contractor shall prepare and conduct a GSE software design review as part of the IPDR and ICDR and provide a review package in accordance with CDRLs RE-3 and RE-4. The Contractor

shall deliver the software used to command the instrument and monitor telemetry during ground testing for the purpose of familiarizing Government operations personnel with instrument command procedures. This shall be a one-time delivery in accordance with the requirements of CDRL SW-10.

6.0   SPACECRAFT INTEGRATION AND TEST

The Contractor shall provide all personnel, equipment, services, and materials necessary to test the OLI at the spacecraft level of assembly, and to support spacecraft integration and testing. When appropriate, this support shall be provided on-site at the spacecraft contractor's facilities. Contractor-provided equipment shall include all GSE, intra-instrument test tees, interrupt boxes, and breakout boxes. For planning purposes, the Contractor shall assume that spacecraft launch readiness date is 16 months after instrument delivery.

6.1   DELIVERY

The Contractor shall provide the personnel, facilities, and hardware necessary to prepare and pack the OLI and its GSE for shipment, and shall be responsible for the transportation and shipment of the material to the designated spacecraft facility. The Contractor shall develop a Packaging, Handling, Storage, and Transportation (PHS&T) Plan and Procedures in accordance with CDRL IT-4 and shall deliver the OLI and GSE in accordance with the Plan. The Contractor shall perform a complete post shipment functional test of the instrument and all GSE.

6.2   INTERFACE TESTING

The Contractor shall provide all personnel and equipment necessary to plan, conduct, and verify readiness to interface the OLI with the spacecraft. The Contractor shall provide on-site personnel as required.

6.3   SPACECRAFT INTEGRATION

The Contractor shall plan, conduct, and provide on-site personnel necessary to integrate the OLI to the spacecraft. The Contractor shall perform the following, at a minimum:

a. Perform safe-to-mate and signal characterization tests on all instruments and GSE prior to electrical mating.
b. Assist and provide advice during OLI-related integration activities and testing conducted by the spacecraft contractor, including alignment and thermal blanket close-outs.
c. Provide the OLI to Spacecraft Integration Procedure Inputs in accordance with CDRL IT-6.
d. Provide the instrument command and telemetry database in accordance with CDRL IT-7.

6.4   SPACECRAFT TESTING

The Contractor shall plan, conduct, and provide on-site personnel necessary to support the spacecraft contractor on a 24/7 basis during spacecraft thermal vacuum testing and at other times as required. The Contractor shall perform the following, at a minimum:

a. Provide on-site support of all performance testing, including real-time monitoring and off-line data analysis, of the instrument after integration on the spacecraft, covering all shifts worked by the spacecraft contractor.

b. Provide personnel to review procedures, provide expertise, witness testing, and interpret data before, during, and after OLI-related ambient and environmental testing conducted by the spacecraft contractor.
c. Provide conversion of instrument GSE command and telemetry procedures for use in spacecraft GSE. Format is to be supplied by the spacecraft vendor.
d. Support and conduct anomaly investigations involving the OLI and implement corrective actions.
e. Assist in writing procedures for end-to-end compatibility tests.

6.5   PERFORMANCE TESTING

The Contractor shall provide all personnel and equipment necessary to plan, analyze, and verify OLI performance at spacecraft ambient and environmental conditions in accordance with the contractor-generated System Performance Verification Plan. The Contractor shall provide on-site personnel on a 24/7 basis during spacecraft thermal vacuum testing and at other times as required. The Contractor shall provide on-site data analysis for all environmental testing on a 24/7 basis, or whenever the spacecraft contractor is working.

6.6   SHIPMENT

The Contractor shall plan and support all OLI-related activities necessary to safely ship the integrated OLI to the launch base.

6.7   CONDITIONAL ACCEPTANCE

The FM-1 OLI will be conditionally accepted at the spacecraft contractor's facility after shipment.

7.0   PRE- AND POST-LAUNCH SUPPORT

7.1   PRE-LAUNCH

7.1.1   Launch Site Support

The Contractor shall be responsible for OLI functional testing and verification in accordance with the System Performance Verification Plan (SPVP) during the launch site test phase. The Contractor shall provide on-site personnel as required. The Contractor shall:

a. Support OLI-related testing conducted by spacecraft contractor.
b. Execute launch site OLI tests and inspections in accordance with the SPVP.
c. Support and conduct anomaly investigations involving the OLI.
d. Supply, transport, and maintain equipment necessary to conduct OLI testing at launch site. The equipment provided by the Contractor shall include test execution, data analysis, and archive equipment.
e. Supply software, test procedures, and any other documentation necessary to conduct OLI testing at launch site.
f. Supply personnel to conduct OLI testing at launch site on a 24/7 basis as required.
g. Support OLI to ground system compatibility testing.
h. Support mission rehearsals as required prior to launch.
i. Provide console support during launch to monitor instrument health and safety.
j. Provide an evaluation of instrument launch readiness in the form of a go/no-go recommendation.

7.1.2   Operations Training

The Contractor shall train operations personnel in OLI operations. The Contractor shall provide one 3-day training class, and training material, conducted by two people at the operations facility. The Contractor shall develop and provide Operations and Maintenance Manuals in accordance with CDRL OO-4. For the training class, the Contractor shall provide Training Manuals in accordance with CDRL OO-6.

7.2   POST-LAUNCH

The Contractor shall provide post-launch verification and test, including provision of on-site personnel at the Mission Control Center (MCC). The Contractor shall, at a minimum:

a. Provide OLI On Orbit Initialization and Validation Plan (OIVP) in accordance with CDRL OO-1.
b. Determine the duration of the instrument outgassing period.
c. Provide sufficient personnel at the MCC on a 24/7 basis during On-Orbit Initialization and Validation (OIV) during instrument check out which is nominally 4 months in duration.
d. Provide support after instrument test as needed.
e. Review OLI post-launch test data.

f. Provide the OLI Orbital Procedures in accordance with CDRL OO-2.
g. Conduct post-launch pre-Initial Operational Capability (IOC) validations in accordance with the Special Test Requirements (STR).
h. Review data and provide analysis during post-IOC Calibration and Validation activities.
i. Investigate on-orbit anomalies that affect OLI specification-related performance parameters and/or anomalies that threaten OLI or spacecraft health and safety.
j. Provide the On Orbit Performance Report in accordance with CDRL OO-5.

7.3   FINAL ACCEPTANCE

Final acceptance of the FM-1 OLI will occur after the post-launch check-out.

7.4   FLIGHT OPERATIONS

The Contractor shall support post-IOC operations as required. The Contractor shall investigate on-orbit anomalies that affect OLI specification-related performance parameters and/or anomalies that threaten OLI or spacecraft health and safety.

7.5   SUSTAINING ENGINEERING

The Contractor shall maintain the OLI EDU for the duration of the contract period. The Contractor shall maintain expertise and apply support to perform analyses, review ground test data and flight data, and operate GSE as required to resolve FM-1 OLI on-orbit anomalies for one year after the end of the on-orbit checkout period.

8.0   **FLIGHT MODEL 2 (FM-2)**

8.1   **FM-2 DEVELOPMENT AND DELIVERY**

The Contractor shall develop and deliver a second OLI Flight Model designated as FM-2. For FM-2, the Contractor shall perform all tasks required for FM-1 in accordance with Sections 1 through 5, Paragraph 6.1, and Sections 10 and 11 of this SOW and provide all deliverables or updates to deliverables as set forth in the Contract Distribution List of the OLI CDRL. The Contractor shall develop and provide Storage Testing Procedures for FM-2 in accordance with CDRL IT-5. The Contractor shall re-use Ground Support Equipment (GSE) developed for FM-1 on FM-2. Final acceptance of the FM-2 OLI will occur after delivery.

9.0   GROUND SUPPORT EQUIPMENT

9.1   CALIBRATION TEST EQUIPMENT

The Contractor shall define, design, build, provide, maintain, document, and ship (as required) all equipment necessary to radiometrically and geometrically calibrate the RBS. The Contractor shall perform tests necessary to demonstrate that all Ground Support Equipment (GSE) is functioning properly and within specification. The Contractor shall ship an appropriate set of this calibration equipment with the OLI as required to support ambient and thermal vacuum tests at the spacecraft contractor's facility.

9.2   MECHANICAL GSE

9.2.1   Instrument-Level

The Contractor shall define, design, build, provide, maintain, and document the instrument-level OLI mechanical GSE throughout the duration of the contract. The instrument mechanical GSE consists of equipment and fixtures required to operate, test, handle, lift, and maintain the OLI at the contractor's facilities. Mechanical GSE also includes equipment required to provide the appropriate thermal and vibration test environments at the contractor's facilities as specified in the MAR/GEVS.

9.2.2   Spacecraft-Level

The Contractor shall define, design, build, provide, maintain, document, and ship the spacecraft-level OLI mechanical GSE throughout the duration of the contract. The spacecraft-level mechanical GSE consists of equipment and fixtures required to operate, test, handle, lift, and maintain the OLI while at the spacecraft contractor's facilities. In addition,

     a. The Contractor shall provide instrument protective covers that protect fragile components from minor impact as well as contamination.
     b. The Contractor shall provide a drill template containing appropriate instrument-to-spacecraft alignment, orientation, and location reference information, in support of spacecraft bus manufacturing.
     c. The Contractor shall provide all unique instrument mounting hardware (e.g., bolts, washers, etc. which have limited-off-the-shelf availability or require a special fabrication lot).

9.3   ELECTRICAL GSE

9.3.1   Instrument-Level

The Contractor shall define, design, provide, maintain, and document the instrument-level OLI electrical GSE throughout the duration of the contract. The instrument electrical GSE consists of the System Test Equipment (STE) and software necessary to command, monitor, and test the OLI at the contractor's facilities and the interface cables from the STE to the OLI. The Contractor shall ship all electrical GSE with the OLI as required to support tests and spacecraft

integration at the spacecraft contractor's facility. The Contractor shall ensure that any necessary OLI-specific GSE can be operated concurrent with the instrument integration to the spacecraft bus.

9.3.2 <u>Spacecraft-Level</u>

The Contractor shall define, design, provide, maintain, document, and ship the spacecraft-level OLI electrical GSE throughout the duration of the contract. The spacecraft-level electrical GSE consists of the System Test Equipment and software necessary to command, monitor, and test the OLI at the spacecraft contractor's facilities and the interface cables from the STE to the OLI. The Contractor shall ship all electrical GSE with the OLI as required to support tests and spacecraft integration at the spacecraft contractor's facility. The Contractor shall ensure that any necessary OLI-specific GSE can be operated concurrent with the instrument integration to the spacecraft bus.

9.3.2.1 Cables, Harnesses, and Connectors

The Contractor shall provide the spacecraft electrical cables and harnesses, for use in testing, in accordance with the OLI-to-spacecraft ICD, In addition:

     a. The Contractor shall provide two sets of mated pairs of interface connectors for each instrument.
     b. The Contractor shall provide captive covers for all instrument connectors that are not mated to harnesses or flight plugs.
     c. The Contractor shall provide static-discharging connector covers, delivered in-place with the instrument.
     d. The Contractor shall provide instrument buffer connectors and connector savers.
     e. The Contractor shall cover all connectors that are not used for flight or for EMI/EMC testing with EMI tight covers.

9.4 SHIPPING, STORAGE, AND PURGE EQUIPMENT

The Contractor shall provide environmentally controlled shipping/storage containers and necessary ancillary equipment for shipment of the EDU and the OLI FMs.

The Contractor shall pack and ship all test and support equipment to the spacecraft integration facility and to the launch site.

The Contractor shall pack and ship all test and support equipment back to the Contractor's facility.

The Contractor shall develop and provide all equipment and materials necessary to purge the OLI during instrument, spacecraft, and launch processing activities.

The Contractor shall determine the required quantity of shipping containers.

10.0   PERFORMANCE ASSURANCE

The Contractor shall develop, implement, and maintain a comprehensive mission assurance program which meets the requirements of the MAR.

10.1   NONCONFORMANCE REPORTING AND CORRECTIVE ACTION

The Contractor shall have a system for identifying, reporting, controlling, and correcting nonconforming hardware and software in accordance with the MAR. The Contractor shall implement a system for documenting and tracking the disposition of all failures in accordance with the MAR and for reporting these failures in Failure/Anomaly Reports in accordance with CDRL SA-4.

10.2   SYSTEM SAFETY

The Contractor shall implement a system safety program in accordance with the MAR. The Contractor shall provide Safety Waiver/Non-Compliance Requests in accordance with CDRL SA-10. The Contractor shall submit all Detailed Test Procedures to be used at GSFC facilities, other integration facilities, or the launch site in accordance with CDRL IT-3. The Contractor shall provide Missile System Pre-Launch Safety Package (MSPSP) Inputs in accordance with CDRL SA-14. This input will be used by the Government to generate the MSPSP for submittal to the launch range.

10.3   RELIABILITY

The Contractor shall plan and implement a reliability program in accordance with the MAR.

10.3.1   Reliability Analyses

The Contractor shall perform and deliver a Reliability Report in accordance with CDRL SA-1. The Contractor shall document a Critical Items List in accordance with CDRL SA-2. The Contractor shall perform parts stress analyses and implement a software reliability program in accordance with the MAR. The Contractor shall perform and deliver Worst Case Analyses in accordance with CDRL SA-3.

10.3.2   Reliability Analyses of Test Data

The Contractor shall trend selected parameters of test data that relate to performance stability and generate trend analyses reports in accordance with the MAR. The Contractor shall merge the systems engineering trend analysis effort with the reliability trend analysis effort into one trending program. The Contractor shall submit to the Government for approval the list of parameters to be trended in accordance with CDRL SE-4. After implementation, tracking and trend analyses reports shall be provided in accordance with CDRL SE-4.

10.4   PARTS

The Contractor shall plan and implement an Electrical, Electronic, and Electromechanical (EEE) parts control program in accordance with the MAR. The Contractor shall have a Parts Control Plan in accordance with the MAR and make it available for review by the Government. The Contractor shall generate and provide a Parts Identification List in accordance with CDRL SA-12.

10.5   GIDEP ALERTS AND PROBLEM ADVISORIES

The Contractor shall participate in the Government/Industry Data Exchange Program (GIDEP) in accordance with the MAR. The Contractor shall provide Responses to Alerts in accordance with CDRL SA-6.

10.6   MATERIALS, PROCESSES AND LUBRICATION

OLI flight material shall meet the requirements of the MAR. The Contractor shall plan and implement a Materials and Processes Control Program in accordance with the MAR. The Contractor shall provide Material Review Board (MRB) Decisions on Non-Conformance in accordance with CDRL SA-5. The Contractor shall provide and maintain Material Identification Lists in accordance with CDRL SA-9. The Contractor shall develop a Mechanism Life Test Plan in accordance with CDRL SA-16. The Contractor shall qualify all lubricated mechanisms by life testing in accordance with the MAR. The Contractor shall provide and maintain a Limited Life Items List in accordance with CDRL SA-8.

10.7   WORKMANSHIP STANDARDS

The Contractor shall plan and implement an Electronics Packaging and Processes Program in accordance with the MAR. The Contractor shall provide Printed Wiring Board Coupons to the Government by arrangement with the COTR.

10.8   CONTAMINATION CONTROL

The Contractor shall develop and deliver a Contamination Control Plan in accordance with CDRL SA-13. The Contractor shall measure and maintain the levels of cleanliness required during each phase of the hardware's lifetime as established by the Contamination Control Plan. The Contractor shall deliver to the Government for analysis any contamination witness samples in accordance with the requirements of the Contamination Control Plan and by arrangement with the COTR.

10.9   PHOTO DOCUMENTATION

The contractor shall provide Photographic and Video Records in accordance with CDRL SA-11.

11.0   <u>SPARES</u>

The Contractor shall define and implement the spares program necessary to minimize schedule impact for the project created by failures, contamination, or by other plausible events or conditions for all flight and ground support equipment, including the EDU. In defining the spares program, the Contractor shall consider the reliability, handling, and environment of subsystems, components, and parts, hence the likelihood that these items would need to be replaced. The Contractor shall provide a Spare Parts List in accordance with CDRL IT-1. The Contractor shall qualify, test, and calibrate the spares to the same level as the corresponding flight parts.